MULTIPLE LAYER INDUCTOR AND METHOD OF MAKING THE SAME

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BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates generally to electronic components, such as inductors. More particularly, the present invention relates to printed multiple layer inductors.

Background Art

[0002] Inductor implementations can be generally classified into two categories: discrete inductors and printed inductors. Discrete inductors (e.g., leaded inductors, surface mounted inductors, and air coil inductors) are generally packaged in containers having terminals that connect to a substrate, such as a printed circuit board (PCB). In contrast, printed inductors are not packaged in a container. Rather, printed inductors include patterns of conductive material disposed on a substrate, such as a PCB.

[0003] Because the integration of discrete inductors onto a PCB requires expensive assembly techniques, electronic products having discrete inductors are more costly than ones having printed inductors.

[0004] Therefore, to minimize the cost of products requiring inductors, it is desirable to use printed inductors. Unfortunately, the replacement of discrete inductors with less expensive printed inductors typically requires a tradeoff in size. This tradeoff occurs for two reasons. First, typical printed inductors must be considerably larger than their discrete inductor counterparts to provide the same inductance value. Second, printed inductors are typically unshielded. As a consequence, minimizing electromagnetic interaction between conventional

printed inductors and other electronic components (such as other inductors) requires these printed inductors to be spaced at greater distances from other electronic components.

[0005] Multiple layer approaches have been employed for printed inductors. One such approach is shown in FIGs. 1A-1B and FIG. 2. As shown in FIGs. 1A-1B, this approach involves two spiral layers 102a and 102b, where each spiral layer 102 is printed on a respective side of a glass-epoxy substrate. The inductor has terminals 112 and 114, which are printed on one of the substrate sides.

[0006] Printed ground planes 104a and 104b provide shielding to spiral patterns 102a and 102b, respectively. These ground planes are connected by apertures known as vias, such as via 106, that penetrate the substrate. As shown in FIGs. 1A and 1B, vias 108 and 110 connect spirals 102a and 102b.

[0007] According to the approach of FIGs. 1A-1B, and 2, the substrate is attached to an aluminum housing or base. FIG. 2 is a side view illustrating the attachment of the substrate (shown as substrate 201) to an aluminum housing 202 having a portion that is aligned with spirals 102. Substrate 201 and housing 202 are attached with a screw 202 that penetrates ground planes 104a and 104b, thereby grounding housing 202. Thus, the aligned portion of housing 202 provides further shielding (referred to herein as bottom shielding) to spiral patterns 102.

[0008] Unfortunately, housing 202 is expensive and bulky. Accordingly, what is needed is a printed inductor implementation that provides inductance values and shielding capabilities that are comparable to discrete inductors without requiring a bulky and expensive housing.

BRIEF SUMMARY OF THE INVENTION

[0009] The present invention is directed to a multiple layer inductor having a first spiral conductive pattern disposed on a first surface; a second spiral conductive pattern disposed on a second surface; a continuing interconnection coupled to the first and second spiral conductive patterns; an interface coupled to the first and

second spiral conductive patterns; and a conductive shield pattern disposed on a third surface that is adjacent to the second surface.

[0010] The interface includes a first terminal disposed on the first surface that is coupled to the first spiral conductive pattern. The interface also includes a second terminal that is disposed on the first surface and coupled to the second spiral conductive pattern.

[0011] The continuing interconnection may include a first via coupled to the first and second spiral conductive patterns; and a second via coupled to the second spiral conductive pattern and the interface.

[0012] Alternatively, the continuing interconnection may include a first via coupled to the first spiral conductive pattern; a second via coupled to the second spiral conductive pattern; and a third spiral conductive pattern disposed on a fourth surface that is coupled to the first and second vias.

[0013] In a further alternative, the continuing interconnection may include a first via coupled to the first spiral conductive pattern; a second via coupled to the second spiral conductive pattern; and a plurality of connected spiral conductive patterns that are each disposed on a respective one of a plurality of adjacent layers. In this alternative, a first of the plurality of spiral conductive patterns is coupled to the first via, and a second of the plurality of spiral conductive patterns is coupled to the second via.

[0014] The spiral conductive patterns may have various orientations according to various schemes. In one such scheme, orientations alternate according to adjacent substrate surfaces.

[0015] The multiple layer inductor may also include a second conductive shield pattern disposed on a fourth surface that is adjacent to the first surface. Furthermore, the multiple layer inductor may include first and second conductive side shield patterns that are disposed on the first and second layers, respectively. These shield patterns may be grounded.

[0016] The present invention is also directed to a method of designing a multiple layer spiral inductor having a plurality of spiral conductive patterns disposed on